[0078] **FIG. 3** shows a schematic view looking down on a chip from above. For descriptive purposes x and y axes are depicted on the figure while the z dimension would point upwards perpendicularly from the page. The north and south poles are indicated on the diamond-shaped magnetic islands, and the localized magnetic field **50** within a gap region is also indicated. The distance g between the ends of the magnetic islands is sufficient to accommodate a bead. In certain embodiments of the invention the localized field traps (immobilizes) a single bead in the gap region between the magnetic islands.

[0079] In this embodiment the chip design involves selection of a number of parameters including (1) the shape and dimensions of the magnetic islands in the x, y, and z directions; (2) the length of the gap between adjacent islands, i.e., the spacing of the islands in the x dimension; (3) the distance between rows of islands in the y dimension. Although these parameters are interrelated, they are discussed separately below for convenience. Other considerations, also addressed below, include the material structure of the magnetic regions and the trapping energy for a magnetic particle.

[0080] (1) Shape and Dimensions of Magnetic Islands

[0081] Although **FIGS. 2 and 3** illustrate a regular arrangement of diamond-shaped magnetic islands, it will be appreciated that the shape and size of the islands may vary as may the spatial relationship between the islands. The islands may be, for example, ovals, rectangles, diamonds, lozenges, polygons, variations on the preceding shapes, etc. In certain embodiments of the invention the islands are oblong. By oblong is meant a shape in which the length and width (i.e., the dimensions in the x and y directions) are not equal. For descriptive purposes, it will be assumed that the length refers to the dimension in the x-direction while the width refers to the dimension in the y-direction as shown in **FIGS. 2 and 3**. Thus the islands depicted in **FIGS. 2 and 3** are oblong, with a length l_{is} greater than their width w_{is}. Under such conditions each island has ends with opposite magnetic polarities when magnetized. Facing ends of adjacent oblong magnetic islands form a localized field **50** as shown in **FIG. 3**.

[0082] **FIG. 4** shows another schematic view of two adjacent magnetic islands separated by a gap of width g. Referring to this figure, the strength of the localized magnetic field H(x,y) produced by the two islands may be approximated as follows (assuming that the width of the gap is constant in the y dimension):

$$H(x,y)=-\nabla\Phi(x,y)$$

$$H_x(x,y)=(H_g/\pi)\tan^{-1}[y/(x^2+y^2-1/4)]$$

$$H_y(x,y)=(-H_g/2\pi)\ln[((x+1/2)^2+y^2)/((x-1/2)^2+y^2)] \quad \text{(Eq. 1)}$$

[0083] In the above equations H stands for magnetic field, Φ stands for magnetic potential, and H_g stands for the saturation field for the magnetic material. x and y are in units of the gap, i.e., a distance equivalent to the width g of the gap has a value of one gap unit. This equation may be used to roughly calculate the strength of the field within the gap and outside the gap. Note that this equation is approximate only, and the exact form of the equation depends upon the geometry of the gap. A more accurate calculation of the magnetic field strengths may be obtained using numerical modeling. For example, the Mathematica® program (and other similar programs) may conveniently be used to model the localized magnetic field produced by magnetic region and gap configurations of different shapes and sizes. One of ordinary skill in the art will readily be able to generate and use such models. **FIG. 5** shows the calculated magnetic field strengths in the x and y directions, assuming a 3 μm gap spacing (g=3 μm) and rectangular cobalt islands. As shown in **FIG. 5**, the field strengths are on the order of 1000 Gauss in the gap region. The magnetic field in the x-direction (pole to pole) is relatively constant and strong in most of the gap, trailing off rapidly outside the gap. The field in the y-direction (both in and out of the gap) is mostly due to the fringing field and averages to zero when integrated over the gap region. The trailing fields outside the gap region have an impact when the magnetic bead is in the process of being trapped, as it diffuses in the vicinity of a gap. Once trapped in the gap, the permeability of a magnetic particle will collapse the field lines mostly into it, leaving a negligible trailing field outside the gap to attract a second bead to the same (filled) gap region.

[0084] As is evident from the foregoing discussion, the absolute and relative strengths of the fields within and outside the gap influence the likelihood that one or more beads will be trapped in or adjacent to the gap. Generally it is desired that only a single bead be trapped in each gap. Accordingly, it may be desirable to select island geometries and spacings that result in a strong field within the gap and a weaker field outside the gap. For example, magnetic field calculations showed that diamond-shaped islands resulted in a strong field within the gap. However, these islands also produced a region of "fringing" field outside the gap, which increased the likelihood of trapping additional beads in the region around the gap. Magnetic islands with a substantially rectangular shape or a rectangular shape with rounded comers or flattened comers (similar to a bar magnet) resulted in reduced fringing fields. **FIG. 6** shows an Atomic Force Microscope (AFM) image of portions of two adjacent magnetic islands and the gap between them according to one embodiment of the invention. In this figure the length of the gap is approximately 3 μm and the width in the y dimension (i.e., the distance between the longer faces of the islands) is on the same order.

[0085] The width w_{is} of the islands is also significant in terms of the likelihood of trapping one or more beads within or adjacent to a gap region. If the width is too great the fringing field may trap additional beads adjacent to a filled gap region. If the width is too small, the field within the gap is reduced and may not be strong enough to efficiently trap a bead in the gap region. The dimensions of the magnetic particles to be used with the chip influence the optimum selection of island width. In certain embodiments of the invention the island width is selected to be approximately the same as the diameter of a spherical bead. For example, if 2.8 μm diameter beads are to be used, an island width of 3 μm may be selected. In certain embodiments of the invention the island width is between 1 and 10 μm, between 1 and 5 μm, between 5 and 10 μm, between 10 and 15 μm, or between 15 and 20 μm. In certain embodiments of the invention the island width is selected to be approximately the same as the diameter of a spherical bead. For example, if 2.8 μm diameter beads are to be used, an island width of 3 μm may be selected. One of ordinary skill in the art will be able to select an appropriate value of w, taking into